Sidewise Technologies:
National Security and Global Power Implications

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IF WE ACCEPT the premise that the latest advances in technology matter the most, looking at comparative international positioning in information technology (IT), biotechnology, nanotechnology, and quantum computing, then we would logically ask: Can the United States keep its lead over other nations in these fields? No doubt developments in these advanced fields are important. Molecular engineering will make materials stronger, allowing faster airplanes and taller buildings. Moore's Law—that because of technological developments in the semiconductor industry, the complexity of integrated circuits doubles every 18 months—will drive faster and ubiquitous computing.[1] But a focus on advanced technologies is misplaced when considering national security and global power questions. Such a focus leaves out a great deal.

Innovation is not restricted to advanced technologies. A focus on biotechnology, nanotechnology, and so on distracts attention from older, mature technologies, which also produce many innovations that forums dealing with the future of technology do not consider. Technologies advance vertically to higher levels of performance and complexity, but they also advance horizontally or sidewise into new markets and applications. This kind of innovation is centered on the application of technology, not on improvements in narrow performance measures like computing speed or microscopic size.

When Toyota and Nissan challenged Ford and General Motors for market supremacy in the 1970s they did not do so with technologically advanced robots. By the 1970s, the automobile industry was a mature industry and every big player had essentially the same technology. What Toyota and Nissan did was to import Detroit's discarded 1960s technology and apply it to inventory, work teams, and quality control. The result was a strategic surprise to Detroit. A similar story could be told about steel and consumer electronics in the 1970s. Americans tend to focus on only one model of technology at a time. Disruptive (revolutionary) technologies are the fashion, but as important as they are, they are not universal models of change. There are many models of technology development.

Sidewise Technologies

Sidewise technologies are mature technologies applied to new problem areas. For "mature," think of dull, old-fashioned technologies that were innovative two generations ago. Such technologies attract little notice from first-rate scientists and engineers and get little or no government support.

The concept of sidewise technologies arose during the 1960s. In a project on South American economic development, Robert Panero, an engineer at the Hudson Institute, noticed that American engineers believed that all of the good South American sites for hydroelectricity had been taken. As a result, the potential for new hydroelectricity was low.[2] But Panero thought about low earth dams as an alternative. A low earth dam, a 10- to 30-foot-high structure of earth and concrete used to hold back a small river, could run a few small generators. American civil engineers dismissed such dams as not worthy of consideration. Low earth dams did not employ the giant concrete intake towers of the high dam; their electrical generating capacity was small; they did not require the design talents of high-tech engineers; and they were not considered safe because most had been designed without elaborate computer calculations of strains and pressure.

What the engineers failed to see was that, given the geography of South America, much more electricity could be generated from such low dams than from a few high dams. South America's major rivers have thousands of tributaries that extend over enormous flat plains. Low dams are easy to construct and can be made quite safe by overengineering them with more earth and concrete. South America had great hydroelectric potential, but when looked at from the conventional advanced-technology perspective, it did not. Low dams were overlooked by a technological culture that envisioned dams as having giant concrete walls and deep intake towers.

Innovation in two-thirds of the world. Who cares about outdated computers, small generators, or 1960s ballistic missiles? The answer is that about two-thirds of the world cares about such technologies because they are better suited for those cultures than are the more advanced products. They are cheaper, simpler, and do not require support systems and institutions that are all but absent in less-advanced nations.

Diesel engines made for the U.S. and European markets now contain many ceramic parts to make them lighter and more fuel efficient, but these environmentally clean, efficient superengines do not sell in China or India. What those markets need are cheap engines that can be repaired in the field without sending the engine to a specialized overhaul facility. A country with bad roads does not require ceramic engines; it needs vehicles with rugged axles and shocks.

Sidewise technologies have a different locus of innovation. Innovation occurs in processes (Japanese autos in the 1970s), application areas (low earth dams), or in combining old technologies in new ways. One example of sidewise technology today is seen in Asia's military modernization, which in many ways is a story about the West's hand-me-downs, Russia's fire sale of old weapons, the U.S. export of second-rate equipment to its allies, and the indigenous developments of missile industries in North Korea and Pakistan. Missiles are especially good examples. For the most part, North Korean missiles are inaccurate, are not made from the latest lightweight materials, and use antiquated propulsion systems. They use metal engine parts that cannot operate at high temperatures and therefore produce lower thrust than the composite engine valves found in U.S. and European designs. But these unglamorous missiles will still carry lethal payloads close enough to their intended targets.

In the West, discussions of technology frontiers tend to ignore older technologies because policymakers usually ask, Are they catching up in technology? Are they going for disruptive technologies? Such questions overlook an important insight: Global shifts of power in the military and other areas can occur even if the United States keeps its lead in advanced technologies. Instead of focusing solely on advanced technologies, we should be asking, How might sidewise technologies affect strategic competition between the United States and other nations? First, however, we must recognize that there is a competition, albeit one in which our competitors are wielding older technologies.

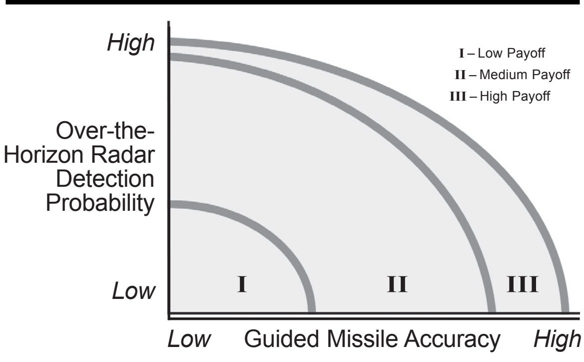
Applying sidewise technologies to national security is new.[3] Right now, our potential adversaries in Asia are doing just that—using sidewise technologies to improve their offensive and defensive capabilities. In particular, they are combining older technologies to create effective weapons systems. Consider the combination of two sidewise technologies, over-the-horizon (OTH) radars and guided missiles. The United States deployed OTH radars in the 1960s as part of its early warning system against Soviet intercontinental ballistic missile

(ICBM) launches. Basically, OTH radars operate at wavelengths refracted by the ionosphere. The technology is an extension of long-distance, high-frequency radio.

The figure shows what engineers call an innovation landscape that depicts the range of benefits to be gained by mating OTH and guided missiles.[4] Roman numerals I, II, and III indicate different innovation regions. Each suggests a locus of innovation payoffs from combining the two technologies in different ways. The three regions show three payoffs from the different combinations where missile accuracy (measured by circular error probability) is good enough to combine with OTH radars whose detection capacity is also good enough. But good enough for what? We can measure the payoff in several different ways. OTH radar in the United States provides early warning of ICBM attacks, but it can also track ships far out at sea. The payoff in the figure (the third dimension of the x, y, and z coordinate system) could be the probability of a hit on a ship. The basic idea is to combine OTH radar with ballistic missiles to target ships. Location data would be linked to the missile, and the tracking information would be used to aim the guided missile or to correct its trajectory midcourse. In this application, the missile could threaten ships even if they were thousands of miles away from the radars.

The implications of such a capacity are considerable and as much political as they are military. China, India, or Iran could radically alter the balance of power in several regions if they had this capability. Just saying this usually raises howls of objection, with doubters claiming that emerging countries often have a great deal of difficulty

Sidewise Technology Landscape for Radars and Missiles



getting the technologies to work together. But the Chinese are currently using the kind of 1960s technology that spawned OTH; it is only a matter of time before they will be able to construct such an anti-ship missile.

Systems integration. Systems integration is another major topic almost always overlooked in Western discussions of technology's implications for national security and global power. This is a mistake. China, India, Iran, or North Korea will be important military competitors not because of the number of missiles and radars they have or because of their advanced technology research and development (R&D), but because they can organize old technologies into a coherent system. If they tie older technologies into an effective organization, the whole will be much greater than the sum of the parts, with enormous strategic implications. If they cannot, they will remain second-rate military powers. We should not bet on the latter.

Most U.S. examinations of technology and global power in emerging countries focus on R&D as a fraction of gross domestic product (GDP); for example, the number of transistors that can be put on a chip or recombinant DNA breakthroughs. I have yet to see an assessment that looks at sidewise technologies and systems integration.

Synchronization, coupling, horizontal integration, and lateral control are words rarely found in U.S. assessments of Asian technology. When asked about China's capacity to coordinate joint forces, a senior U.S. Government official who specializes in China said they will never be able to do it. I pointed out that we know next to nothing about China's capacity in this area; we do not collect information about it, and we do not have the templates to assess it or the vocabulary to describe it. He said the ability to coordinate complex projects depends on democratization and free markets, and only after democratic modernization would China be able to integrate systems. While well-meaning, the official unwisely assumed that China's culture was like that of the United States. An organization's truth depends on the categories and classifications the organization uses. A fish does not know that it lives in water. Surrounded as we are by advanced technologies and immersed in the competition for cutting-edge breakthroughs, we overlook mature technologies and the consequences of combining them in new ways.

Preempting surprise. Events for which we have no organizational vocabulary surprise us the most. Sidewise technologies, which are not usually part of the technological landscape Americans look at, stretch beyond standard categories and questions. The United States has the best technologies in the world and can stay ahead with Federal support of universities and R&D, which answers the question about leadership in technology; however, our technological preeminence does not guarantee political or military preeminence.

Technological surprise is a result of blindspots that keep us from seeing certain regions of the innovation landscape. Combinations of sidewise technologies are likely to surprise us because we do not look for them. We do not assess whether or not they can be combined into functioning systems. Sputnik is one model of technological surprise, but only one. Surprise also arises from the failure to see key combinations.

Advanced technologies matter a great deal. In some cases old systems are easier to replace wholesale with advanced technologies. Because using cell phones is cheaper than wiring Asia with copper lines, some Asian military establishments will exploit cell phones' advanced features. We must take all of these factors into account. The developing world will not abstain from using advanced technologies, but they will buy into them only in selected instances.

Implications

Analysts must look at the entire technology innovation landscape, not just the regions our own culture values. Technology's momentum in two-thirds of the world comes from improvements and combinations of simple technologies. Moreover, system integration of sidewise technologies is likely to be a great deal easier than the system integration challenges the United States faces. To project our complexities onto other countries is to overestimate the challenges they face. Most countries are modernizing, which means they will gradually learn how to integrate systems better. They might not be able to deploy a global missile defense system, but they might well be able to field systems that deny freedom of maneuver to the United States.

We must advance our understanding of these processes through case studies of sidewise technological competition. In the 1980s, the appropriate technology movement, a systematic effort to explore case studies of technology transfer from the developed to the developing world, arrived at many fascinating insights. The many cases of sidewise technological competition that have occurred in the business world can also be mined for insights.

Scientists in the most advanced fields might not be good at describing the technology of the future because of their deep understanding of the specifics of today's technology. In the 1950s, there were two competitors in computing, IBM® and UNIVAC.® UNIVAC had the country's top mathematicians and scientists on their team and had originally developed computers. IBM had marketing people. You know the outcome.[5]

Overlooking sidewise technologies might lead to seriously underestimating the economic growth potential of the developing world. In the 1970s, General Motors did not see Toyota coming, and U.S. Steel did not recognize competition from South Korea. Capital stocks can probably modernize much faster with sidewise than with advanced technologies. We are likely to overlook the capacity for innovation because from the U.S. perspective the technology is "backward." Anticipating the effects of technology is difficult. Trying to do so with a Western outlook is even more misleading. What is needed is a conceptual framework more focused on the cultures and needs of most of the world. We must understand that Western technology diffuses to the rest of the world by moving sidewise, not disruptively. ***MR***

NOTES

1. Moore's Law is an empirical observation stating, in effect, that at our rate of technological development and advances in the semiconductor industry, the complexity of integrated circuits doubles every 18 months. See on-line at <www.google.com/search?hl=en&lr=&oi=defmore&q=define:Moores+Law>, accessed 7 September 2005.
2. John G. Mitchell, *The Man Who Would Dam the Amazon* (Lincoln: University of Nebraska Press, 1990), 1-40.
3. Paul Bracken, Linda Brandt, and Stuart E. Johnson, *The Changing Landscape of Defense Innovation*, forthcoming from Defense Horizons, on-line at <www.ndu.edu/ctnsp/defense_horizons.htm>, accessed 14 June 2005.
4. Lee Fleming and Olav Soreson, "Navigating the Technology Landscape of Innovation," *Sloan Management Review* (Winter 2003): 15-23.
5. See Seth Godin, *Free Prize Inside: The Next Big Marketing Idea* (New York: Penguin USA Portfolio, 2004).

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